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Econometric analysis of income, productivity and diversification among smallholders in Brazil

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ABSTRACT

Family farming plays important roles in agricultural production and the world's food security. This paper provides an econometric analysis of income, productivity and diversification of Brazilian smallholders. Using the most updated data from the Ministry of Agrarian Development (MDA) enables a more precise analysis than traditional agri-census data. The database contains approximately 4.7 million family farmers from all regions of the country. We used linear and tobit regression to untangle useful information behind these large datasets. The results demonstrated that the smallholders that are part of an agricultural cooperative or a member of a farmer's association positively affect income, productivity and diversification. The age of household heads is shown to have a non-linear relationship in the three cases, while the household head being female presented a negative effect in all regressions. Although recent technical assistance showed negative impacts on income and productivity, farmer's assistance positively affected the likelihood of a smallholder diversifying their production and, therefore, becoming less subject to price imbalances. The results support current views in the field of smallholder farming while presenting marked regional differences of a continental country, enabling policy makers to make better, more informed decisions.

1. Introduction

The importance of smallholder agriculture has become more evident for food production in the past few years, where smallholders are mainly composed of family farmers. This group has been recognized as extremely important for global food security, particularly after the 2014 United Nations' (UN) Year of Family Farming. Because of growing concerns in food security, some important measures to strengthen smallholder's agriculture can already be seen, such as in the development of public policies and increasing investments targeting this sector (Bosc et al., 2013). The important contribution of family farmers to the world's agricultural production is evident. Therefore, this contribution must be encouraged and enhanced.

There is no universal definition of a family farm. Formerly, only properties with less than two hectares were considered smallholders. However, this definition is based only on property size and does not represent the reality. This concept has evolved and, despite definitions varying between countries, some issues are considered essential; for example, there needs to be a property held by a family with only or mostly family labor, and that labor should produce a large share of their income. According to this definition, smallholding is the prevalent form of farming globally; approximately 90% of all farms in the world are considered family farms and are responsible for producing most of the world's food (Berdegué and Fuentealba, 2011; Graeub et al., 2016).

According to the Food and Agriculture Organization (FAO) of the United Nations – FAO (2014), there are at least 500 million family farms in the world that support almost 2 billion people who depend on these farms for their livelihood. The large majority of these farms are very small; 72% are less than one hectare and only 1% are bigger than 50 ha. In Brazil, there are approximately 4.7 million family farmers who

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own a total of 89 million hectares and support 17 million people (Bosc et al., 2013; Herrera et al., 2017). As in other countries, smallholders in Brazil are essential not only for their production, which in 2006 accounted for 38% of the gross value of agriculture, but also because they help the country to ensure the supply for the domestic market and maintain its position as a dominant agricultural exporter, according to the Brazilian Institute of Geography and Statistics – IBGE (2006).

There are increasing concerns about the growing global demand for food in the next few decades, particularly in the face of climate change. Closing this food shortage gap will place additional stress on land, water and biodiversity, which are already scarce or are showing signs of degradation in several countries (FAO, 2014). Market requirements are showing that it is not enough to produce more food, but that the production needs to be done with an emphasis on sustainability. The efficiency of smallholder farming relative to larger farms has been widely documented (Bosc et al., 2013); smallholders can achieve high production levels using family labor in diversified production systems. Therefore, these 500 million family farmers are the key to ensuring the world's food security and environmental sustainability (FAO, 2014).

In line with the size and importance of family farming to the world, this sector needs to be constantly monitored. As stated by Bosc et al. (2013), up-to-date information on the smallholder sector is important for the purpose of strategic investments and to strengthen this group. To contribute to those goals, this study analyses family farming in Brazil using the most current data available. Most of the studies of this sector in Brazil are based on the Agricultural Census, which was last conducted by the IBGE in 2006. However, our approach uses the Ministry of Agrarian Development (MDA) cadaster from 2014. Studies using data from the MDA are scarce since there is a restrictive bureaucracy involved in obtaining these data compared to the Agricultural Census, from which data are easily accessed.

By focusing on income, productivity and diversification, this paper aims to better understand the determinants of these three key points for family farmers and the world's future. Actions to empower and increase smallholder's income are key in reducing high poverty rates and gender inequalities in rural areas. Improvements in productivity are crucial to attending to the growing demand for food. While diversification is important for family farmer's income security, the practice enhances sustainability in agriculture, since diversification can value rare seeds and form seed cooperatives, enlarging the diversity of cultivated species (Bosc et al., 2013; FAO, 2014). Our paper is organized as follows. The next section presents the data source and describes the methodology. The econometric techniques and the variables considered. Then, the empirical results are presented and the findings are discussed. The final section provides conclusions and recommendations for future research.

2. Materials and methods

2.1. Data source

The data analyzed in this article were obtained through the MDA in October 2014 and are from a dataset form known as the "DAP" (Declaration of Aptitude to Pronaf), which is mandatory for all family farmers in Brazil who wish to have access to public financing, special subsidies and other policies available to those in this category. Smallholders from every state in the country can fill in their declaration forms on authorized organizations, and after its correct completion, the form is immediately sent electronically to the MDA system. Subsequently, the DAP is checked to identify any mistakes or misleading information. The farmers must communicate any changes related to their properties and are not allowed to go more than three years without updating their DAPs. Therefore, the data extracted from the database contain information that may have been inserted on the same day or as far back as three years ago. This is a useful timeframe for agricultural cycles.

The information provided by the farms in the DAP form is very detailed and includes social and technical variables, such as age, gender, schooling, area of the farm, number of crops produced and total income, among others. To carry out the analysis, we refined the database, removing cases with missing or distorted values (outliers) in order to minimize type 1 and type 2 errors. Approximately 3% (133,000 DAPs) were excluded, and the final database used for this study contained approximately 4.7 million cases. Therefore, it creates a plentiful source of information about family farming in Brazil (a description of all variables can be found in Table 1).

Table 1
Variables description and summary statistics.

Variable	Description	Mean	Std. Dev.
Land owner	Dummy (0, 1)	0.6243	0.4842
Gender	HH Dummy (1 male, 2 female)*	1.3720	0.4833
Age	HH Age in years	44.8358	15.2110
Area	Total area of the farm in hectares	19.0604	33.3236
Income	Total on-farm income in BRL	18404.13	37667.88
Diversification	Simpson index value	0.3529	0.2821
Cooperative	Dummy (0, 1)	0.0497	0.2175
Rural assistance	Dummy (0, 1)	0.0768	0.2663
Region 1	North dummy (0, 1)	0.0945	0.2925
Region 2	Northeast dummy (0, 1)	0.6144	0.4867
Region 3	Southeast dummy (0, 1)	0.1188	0.3235
Region 4	South dummy (0, 1)	0.1421	0.3492
Region 5	Central-west dummy (0, 1)	0.0300	0.1706
Income social benefits	Income from social benefits in BRL	861.1216	3666.725
Income off-farm	Total off-farm income in BRL	376.4161	2749.629
Age^2	Age squared	2241.631	1474.818
Hired work force	Number of hired work force in days/man	3.6980	1.7514
Schooling 1	HH schooling. Literate dummy (0, 1)	0.0631	0.2432
Schooling 2	HH schooling. Elementary school completed dummy (0, 1)	0.8600	0.3469
Schooling 3	HH schooling. High school completed dummy (0, 1)	0.1898	0.3921
Schooling 4	HH schooling. College completed dummy (0, 1)	0.0764	0.2657
Productivity	Productivity BRL/ha	8345.119	334852.2

*HH (Household head).

2.2. Linear regressions

We applied two linear regressions in order to identify determinants of income and productivity, considering that these two dependent variables have continuous values. According to Wooldridge (2015), regression techniques allow us to explore and infer the relation between a dependent variable and specific independent variables. The basic equation is given by the formula:

$$y = c + \beta x + \varepsilon \tag{1}$$

where $\boldsymbol{x}$ is the explanatory variable (independent), $\boldsymbol{y}$ is the explained or dependent variable and $\boldsymbol{\varepsilon}$ is the error that corresponds to the deviation between the real value and the approximate value of y and c is the constant that represents the value of y when x is equal to zero. The coefficients $\boldsymbol{\beta}$ and $\boldsymbol{c}$ are obtained by the least squares method using the following formulas:

$$\beta = \frac{n.\sum_{i=1}^{n} XiYi - \sum_{i=1}^{n} Xi \sum_{i=1}^{n} Yi}{n.\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} Xi\right)^2} \tag{2}$$

$$C = \frac{\sum_{i=1}^{n} Yi - \beta \sum_{i=1}^{n} Xi}{n} \tag{3}$$

The quality and adjustments of the values obtained in the regression are measured with the $\mathbf{R^2}$ index. The dependent variables "income" and